

work, to meet the study objective, the horizontal curve features which affect traffic safety and operation were first identified. From the determined features, currently used countermeasures for enhancing safety and operations were determined. Finally cost-effective countermeasure guidelines and a methodology were developed to apply to particular curve sections. Analyses of a 10,900 horizontal curve data set from Washington State and a 3,277 curve data set from FHWA were performed with respect to curve features and crashes to estimate their relationships and to develop accident reduction factors (ARFs).

Through a variety of statistical methods, the Zegeer, et. al. study developed a crash prediction model consisting of six variables related to crashes and curve features was drawn. The variables found to be significantly related to the number of curve crashes included the degree of curve, roadway width, curve length, ADT, presence of a spiral, superelevation, and roadside condition. Based on the model, geometric improvements which were determined to reduce curve crashes included curve flattening, widening lanes and shoulders, adding spiral transitions, improving deficient superelevation, and making certain types of roadside improvements. Although that study did not specifically evaluate TCD's in terms of crash effects, the authors did discuss the relevance of such measures in the study recommendations:

...."Special attention to signing and markings is important along any highway, and particularly at critical locations such as sharp curves .It is clear, however, that the addition of signing, marking and delineation cannot be expected to solve a safety problem on a poorly designed curve. At the same time, proper signing, marking, and delineation in accordance with the Manual on Uniform Traffic Control Devices (MUTCD) is an essential ingredient to treating hazardous curves in conjunction with other improvements (e.g., clearing roadsides, widening the roadway, paving the shoulder, flattening the curve, and/or improving the superelevation). Even if construction or reconstruction of a poorly designed curve is not feasible, substandard signing, marking, and delineation should still be improved on hazardous curves."

During the past few years, there has been a variety of research on raised pavement markers (RPMs). In 2001, Hammond and Wegmann (2001) evaluated the effect of RPMs on motorists on horizontal curves. The RPMs are traffic control devices used to increase the visibility of changing roadway alignment. The authors derived relationships between RPM applications and driver behavior (the level of opposing-lane encroachment). Under dry weather and daylight conditions, a total of 600 data points of vehicle speed and encroachment were obtained from two horizontal curve segments located in Knoxville, TN. To quantify the effects of RPMs and verify the significance of the collected data, three types of statistical methods were utilized including F-test, Tukey test, and Chi-square test. From the statistical analysis, the results indicated that the level of encroachment decreased after installation of RPMs but the RPMs did not affect average operating speeds on horizontal curves. From this study, the authors recommended the 40 ft spacing of RPMs to prevent encroachment into the opposing lane. However, a shorter spacing than 40 ft is not cost-effective in daylight conditions.

Traffic engineers have continuously looked for the ways to increase the conspicuity of TCDs. Yellow warning signs, one of the important types of TCDs, play a role in notifying drivers of potentially dangerous conditions. Moreover, as fluorescent yellow sheeting method was recently introduced, the effectiveness has been evaluated in various ways. Eccles and Hummer (2000)